MATHEMATICS VERTICAL ARTICULATION TOOL (MVAT)
2016 *Mathematics Standards of Learning* - Patterns, Functions and Algebra
Kindergarten-Algebra II Progression

KEY TO COLORED BOXES: **ES** = K-5 Prior Knowledge Concepts; **MS** = 6-8 Prior Knowledge Concepts; **HS** = 9-12 Prior Knowledge Concepts; N/A = No Concepts Listed

Grade K	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Related to Algebra 1	Related to Algebra 2	EQUALITY/SOLVING EQUATIONS
	1.15										demonstrate an understanding of equality through the use of the equal symbol
		2.17									demonstrate an understanding of equality through the use of the equal symbol = and the use of the not equal symbol
			3.17								create equations to represent equivalent mathematical relationships
				4.16							recognize and demonstrate the meaning of equality in an equation
					5.19b						write an equation to represent a given mathematical relationship, using a variable
					5.19d						create a problem situation based on a given equation, using a single variable
						6.13					solve one-step linear equations in one variable, including practical problems
							7.12				solve two-step linear equations in one variable, including practical problems
								8.17			solve multistep linear equations in one variable with the variable on one and both sides of the equation, including practical problems
									A.4a		solve multistep linear equations in one variable algebraically
									A.4b		solve quadratic equations in one variable algebraically
									A.4c		solve literal equations for a specified variable
									A.4d		solve systems of two linear equations in two variables algebraically and graphically
									A.4e		solve practical problems involving equations and systems of equations
										AII.3a	solve absolute value linear equations

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Grade K	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Related to Algebra 1	Related to Algebra 2	**EQUALITY/SOLVING EQUATIONS**
										AII.3b	solve algebraically and graphically, quadratic equations over the set of complex numbers
										AII.3c	solve algebraically and graphically, equations containing rational algebraic expressions
										AII.3d	solve algebraically and graphically, equations containing radical expressions
										AII.4	solve systems of linear-quadratic and quadratic-quadratic equations, algebraically and graphically

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K-8 Cross-Strand Connections – Equality/Solving Equations

Number and Number Sense Connections

6.3c - identify and describe absolute value of integers
7.1d - determine square roots of perfect squares
7.1e - identify and describe absolute value of rational numbers
8.2 - describe the relationships between the subsets of the real number system
8.3b - determine both the positive and negative square roots of a given perfect square

Computation and Estimation Connections

K.6 – single step story and picture problems – addition/subtraction
1.6 & 1.7 – single step story and picture problems – addition/subtraction
2.5 & 2.6 – practical problems with addition/subtraction with whole numbers
3.3, **3.4**, **3.5** – practical problems with whole numbers; practical problems add/sub fractions
4.4, **4.5**, **4.6** – computation with fractions and mixed numbers, whole numbers, decimals and practical problems
5.4, **5.5**, **5.6**, **5.7** – solve practical problems using operations with whole numbers, fractions, mixed numbers, decimals; apply order of operations
6.5 & 6.6 – solve practical problems using operations with rational numbers; operations with integers; solve practical problems using operations with integers
7.2 – solve practical problems using operations with rational numbers
8.4 – solve practical problems involving consumer applications

Measurement and Geometry Connections

Probability and Statistics Connections

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Grade K	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Related to Algebra 1	Related to Algebra 2	SOLVING INEQUALITIES
						6.14a					represent a practical situation with a linear inequality in one variable; and
						6.14b					solve one-step linear inequalities in one variable and graph the solution on a number line
							7.13				solve one- and two-step linear inequalities in one variable, including practical problems, and graph the solution on a number line
								8.18			solve multistep linear inequalities in one variable with the variable on one and both sides of the inequality symbol, including practical problems, and graph on a number line
									A.5a		solve multi-step linear inequalities in one variable algebraically and represent the solution graphically
									A.5b		represent the solution of linear inequalities in two variables algebraically and graphically
									A.5c		solve practical problems involving inequalities; and
									A.5d		solve systems of inequalities algebraically and graphically
										AII.3a	solve absolute value linear inequalities

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K-8 Cross-Strand Connections – Solving Inequalities

Number and Number Sense Connections

K.2a - compare and describe one set as having more, fewer, or the same number of objects as the other set(s)

1.2b - compare two numbers between 0 and 110 represented pictorially or with concrete objects, using the words greater than, less than or equal to

3.2c - compare fractions having like and unlike denominators, using words and symbols (>, <, =, or ≠), with models

Computation and Estimation Connections

Measurement and Geometry Connections

6.8a - identify the components of the coordinate plane

Probability and Statistics Connections

1.12b - read and interpret data displayed in tables, picture graphs, and object graphs, using the vocabulary more, less, fewer, greater than, less than, and equal to

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Grade K	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Related to Algebra 1	Related to Algebra 2	ALGEBRAIC EXPRESSIONS
					5.19a						investigate/describe the concept of variable
					5.19c						use a variable expression to represent a verbal quantitative expression involving one operation
							7.11				evaluate algebraic expressions for given replacement values of the variables
								8.14a			evaluate an algebraic expression for given replacement values of the variables
								8.14b			simplify expressions in one variable
									A.1a		represent verbal quantitative situations algebraically
									A.1b		evaluate algebraic expressions for given replacement values of the variables
									A.2a		perform operations on polynomials, including applying laws of exponents to perform operations on expressions
									A.2b		perform operations on polynomials, including adding, subtract, multiply, and divide polynomials
									A.2c		perform operations on polynomials, including factoring first- and second-degree binomials and trinomials in one variable
									A.3a		simplify square roots of non-negative rational numbers and monomial algebraic expressions;
										AII.1a	add, subtract, multiply, divide and simplify rational algebraic expressions
										AII.1b	add, subtract, multiply, divide and simplify radical expressions containing rational numbers and variable, and expressions contain rational exponents
										AII.1c	factor polynomials completely in one or two variables
										AII.2	perform operations on complex numbers, express the results in simplest form using patterns of i

K-8 Cross-Strand Connections – Algebraic Expressions

Number and Number Sense Connections

7.1d - determine square roots of perfect squares
8.3a - estimate and determine the two consecutive integers between which a square root lies
8.3b - determine both the positive and negative square roots of a given perfect square

Computation and Estimation Connections

3.4d - solve single-step practical problems involving multiplication of whole numbers, where one factor is 99 or less and the second factor is 5 or less
4.5a - determine common multiples and factors, including least common multiple and greatest common factor
1.6 - create and solve single-step story and picture problems using addition and subtraction within 20
2.5a - recognize and use the relationships between addition and subtraction to solve single-step practical problems, with whole numbers to 20
2.6c - create and solve single-step and two-step practical problems involving addition and subtraction
3.5 - solve practical problems that involve addition and subtraction with proper fractions having like denominators of 12 or less
4.4d - create and solve single-step and multistep practical problems involving addition, subtraction, and multiplication, and single-step practical problems involving division with whole numbers
4.5c - solve single-step practical problems involving addition and subtraction with fractions and mixed numbers
4.6b - solve single-step and multistep practical problems involving addition and subtraction with decimals
5.4 - create and solve single-step and multistep practical problems involving addition, subtraction, multiplication, and division of whole numbers
5.5b - create and solve single-step and multistep practical problems involving addition, subtraction, and multiplication of decimals, and create and solve single-step practical problems involving division of decimals
5.6a - solve single-step and multistep practical problems involving addition and subtraction with fractions and mixed numbers
5.6b - solve single-step practical problems involving multiplication of a whole number, limited to 12 or less, and a proper fraction, with models
5.7 - simplify whole number numerical expressions using the order of operations
6.5a - multiply and divide fractions and mixed numbers
6.5b - solve single-step and multistep practical problems involving addition, subtraction, multiplication, and division of fractions and mixed numbers
6.5c - solve multistep practical problems involving addition, subtraction, multiplication, and division of decimals
6.6a - add, subtract, multiply, and divide integers
6.6b - solve practical problems involving operations with integers
6.6c - simplify numerical expressions involving integers

Measurement and Geometry Connections

Probability and Statistics Connections

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Grade K	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Related to Algebra 1	Related to Algebra 2	**PROPORTIONAL AND ADDITIVE RELATIONSHIPS; SLOPE; LINEAR FUNCTIONS**
						6.12a					represent a proportional relationship between two quantities, including those arising from practical situations;
						6.12b					determine the unit rate of a proportional relationship and use it to find a missing value in a ratio table;
						6.12c					determine whether a proportional relationship exists between two quantities;
						6.12d					make connections between and among representations of a proportional relationship between two quantities using verbal descriptions, ratio tables, and graphs.
							7.10a				determine the slope, m, as rate of change in a proportional relationship between two quantities and write an equation in the form $y=mx$ to represent the relationship
							7.10b				graph a line representing a proportional relationship between two quantities given the slope and an ordered pair, or given the equation in $y=mx$ form where m represents the slope as rate of change;
							7.10c				determine the y-intercept, b, in an additive relationship between two quantities and write an equation in the form $y = x + b$ to represent the relationship;
							7.10d				graph a line representing an additive relationship between to quantities given the y-intercept and an ordered pair, or given the equation in the form $y = x + b$, where b represents the y-intercepts;
							7.10e				make connections between and among representations of proportional or additive relationships between two quantities using verbal descriptions, tables, equations, and graphs
								8.16a			recognize and describe the graph of a linear function with a slope that is positive, negative, or zero
								8.16b			identify the slope and y-intercept of a linear function given a table of values, a graph, or an equation in y = mx + b form;
								8.16c			determine the independent and dependent variable, given a practical situation modeled by a linear function;
								8.16d			graph a linear function given the equation in y = mx + b form; and
								8.16e			make connections between and among representations of a linear function using verbal descriptions, tables, equations, and graphs.
									A.6a		determine the slope of a line when given an equation of the line, the graph of the line, or two points on the line;

Grade K	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Related to Algebra 1	Related to Algebra 2	PROPORTIONAL AND ADDITIVE RELATIONSHIPS; SLOPE; LINEAR FUNCTIONS
									A.6b		write the equation of a line when given the graph of the line, two points on the line, or the slope and a point on the line; and
									A.6c		graph linear equations in two variables
									A.8		given a data set or practical situation, students will analyze a relation to determine whether a direct-variation exists, and represent a direct variation algebraically and graphically
										AII.5	investigate and apply the properties of arithmetic and geometric sequences and series to solve practical problems, including writing the first *n* terms, determining the *n*th term and evaluating summation formulas.
										AII.6 b	**For absolute value, square root, cube root, rational, polynomial, exponential, and logarithmic functions, the student will** use knowledge of transformations to convert between equations and the corresponding graphs of functions.

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K-8 Cross-Strand Connections – Proportional and Additive Relationships; Slope; Linear Functions

Number and Number Sense Connections

K.4a - recognize and describe with fluency part-whole relationships for numbers up to 5
K.4b - investigate and describe part-whole relationships for numbers up to 10
1.7a - recognize and describe with fluency part-whole relationships for numbers up to 10
2.2a - count forward by twos, fives, and tens to 120, starting at various multiples of 2, 5, or 10
2.5 - recognize and use the relationships between addition and subtraction to solve single-step practical problems, with whole numbers to 20
4.2b - represent equivalent fractions
4.5a - determine common multiples
6.1 - represent relationships between quantities using ratios, and will use appropriate notations, such as ab , a to b, and a:b

Computation and Estimation Connections

Measurement and Geometry Connections

6.8a - identify the components of the coordinate plane

Probability and Statistics Connections

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Grade K	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Related to Algebra 1	Related to Algebra 2	PATTERNS, RELATIONS AND FUNCTIONS
K.12											sort and classify objects according to attributes.
K.13											identify, describe, extend, create and transfer repeating patterns.
	1.13										sort and classify objects according to one or more attributes
	1.14										identify, recognize, describe, extend, and transfer growing and repeating patterns.
		2.16									identify, describe, create, extend, and transfer patterns found in objects, pictures, and numbers
			3.16								identify, describe, create, extend, and transfer patterns found in objects, pictures, numbers, and tables.
				4.15							identify, describe, create, and extend patterns found in objects, pictures, numbers, and tables.
					5.18						describe and express the relationship of number patterns found in objects, pictures, numbers, and tables
								8.15a			determine whether a given relation is a function
								8.15b			determine domain and range of a function
									A.7a		**Investigate and analyze function families and their characteristics both algebraically and graphically, including** determining whether a relation is a function
									A.7b		domain and range
									A.7c		zeros
									A.7d		intercepts
									A.7e		values of a function for elements in its domain
									A.7f		connections between any two representations of functions, including concrete/verbal/numeric/graphic/algebraic

Grade K	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Related to Algebra 1	Related to Algebra 2	PATTERNS, RELATIONS AND FUNCTIONS
										AII.6a	**For absolute value, square root, cube root, rational, polynomial, exponential, and logarithmic functions** recognize the general shape of function families
										AII.6b	use knowledge of transformations to convert between graphic and symbolic forms of functions
										AII.7a	**The student will investigate and analyze linear, quadratic, absolute value, square root, cube root, rational, polynomial, exponential and logarithmic function families algebraically and graphically. Key concepts include:** domain and range, and continuity
										AII.7b	intervals in which a function is increasing or decreasing
										AII.7c	maxima and minima
										AII.7d	investigate and analyze linear, quadratic, absolute value, square root, cube root, rational, polynomial, exponential and logarithmic function families algebraically and graphically. Key concepts include: zeros
										AII.7e	intercepts
										AII.7f	values of a function for elements in its domain
										AII.7g	connections between any two representations of function including concrete, verbal, numeric, graphic, and algebraic;
										AII.7h	end behavior;
										AII.7i	vertical and horizontal asymptotes;
										AII.7j	inverse of a function; and
										AII.7k	composition of functions algebraically
										AII.8	Investigate and describe the relationships among solutions of an equation, zeros of a function, *x*-intercepts of a graph, and factors of a polynomial expression.

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Cross-Strand Connections – Relations and Functions

Number and Number Sense Connections

6.1 – represents relationships between quantities using ratios

Computation and Estimation Connections

6.4 - recognize and represent patterns with whole number exponents and perfect squares

Measurement and Geometry Connections

Probability and Statistics Connections

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Application of Properties of Real Numbers[1] - Patterns, Functions, and Algebra Strand

✔ = property can be applied in this standard; N/A = not applicable

Standard of Learning Description	Solve One-Step Linear Equations **6.13**	Solve One-Step Linear Inequalities (addition/subtraction only) **6.14b**	Evaluate Algebraic Expressions **7.11**	Solve Two-Step Linear Equations **7.12**	Solve One- and Two-Step Linear Inequalities **7.13**	Evaluate/Simplify Algebraic Expressions **8.14a,b**	Solve Multistep Linear Equations **8.17**	Solve Multistep Linear Inequalities **8.18**
Commutative Property of Addition $a + b = b + a$	✔	✔	✔	✔	✔	✔	✔	✔
Commutative Property of Multiplication $ab = ba$	✔	✔	✔	✔	✔	✔	✔	✔
Associative Property of Addition $(a + b) + c = a + (b + c)$			✔			✔	✔	✔
Associative Property of Multiplication $(ab)c = a(bc)$			✔			✔	✔	✔
Distributive Property (over addition/subtraction) $a(b + c) = ab + ac$ and $a(b - c) = ab - ac$			✔			✔	✔	✔
Identity Property of Addition $a + 0 = a = 0 + a$	✔	✔	✔	✔	✔	✔	✔	✔
Identity Property of Multiplication $a \cdot 1 = a = 1 \cdot a$	✔	✔	✔	✔	✔	✔	✔	✔
Inverse Property of Addition $a + (-a) = 0 = (-a) + a$	✔	✔	✔	✔	✔	✔	✔	✔
Inverse Property of Multiplication $a \cdot \dfrac{1}{a} = 1 = \dfrac{1}{a} \cdot a, a \neq 0$	✔	✔	✔	✔	✔	✔	✔	✔
Multiplicative Property of Zero[†] $a \cdot 0 = 0 \cdot a$	✔		✔	✔	✔	✔	✔	✔
Substitution Property[†] If $a = b$, then b can be substituted for a in any expression, equation or inequality	✔	✔	✔	✔	✔	✔	✔	✔

[1]The properties of real numbers listed apply given *a*, *b*, and *c* are real numbers. In some standards, limitations may exist on the values of *a*, *b*, or *c* (e.g., integers only or rational numbers only), or impose other parameters (e.g., one-step equations) that may prevent situations in which a property could be applied. [†]Multiplicative Property of Zero and the Substitution Property may also be considered properties of equality/inequality.

Application of Properties of Equality/Inequality[2] - Patterns, Functions, and Algebra Strand

✓ = property can be applied in this standard; N/A = not applicable

Standard of Learning Description	Solve One-Step Linear Equations **6.13**	Solve One-Step Linear Inequalities (addition/ subtraction only) **6.14b**	Solve Two-Step Linear Equations **7.12**	Solve One- and Two-Step Linear Inequalities **7.13**	Solve Multistep Linear Equations **8.17**	Solve Multistep Linear Inequalities **8.18**
Addition Property of Equality If $a = b$, then $a + c = b + c$	✓		✓		✓	
Subtraction Property of Equality If $a = b$, then $a - c = b - c$	✓		✓		✓	
Multiplication Property of Equality If $a = b$, then $ac = bc$	✓		✓		✓	
Division Property of Equality If $a = b$ and $c \neq 0$, then $\frac{a}{c} = \frac{b}{c}$	✓		✓		✓	
Addition Property of Inequality If $a < b$, then $a + c < b + c$; If $a > b$, then $a + c > b + c$		✓		✓		✓
Subtraction Property of Inequality If $a < b$, then $a - c < b - c$; If $a > b$, then $a - c > b - c$		✓		✓		✓
Multiplication Property of Inequality If $a < b$ and $c > 0$, then $ac < bc$; If $a > b$ and $c > 0$, then $ac > bc$; If $a < b$ and $c < 0$, then $ac > bc$; If $a > b$ and $c < 0$, then $ac < bc$				✓		✓
Division Property of Inequality If $a < b$ and $c > 0$, then $\frac{a}{c} < \frac{b}{c}$; If $a < b$ and $c < 0$, then $\frac{a}{c} > \frac{b}{c}$ If $a > b$ and $c > 0$, then $\frac{a}{c} > \frac{b}{c}$; If $a > b$ and $c < 0$, then $\frac{a}{c} < \frac{b}{c}$				✓		✓
Substitution Property If $a = b$, then b can be substituted for a in any expression, equation or inequality	✓	✓	✓	✓	✓	✓

[2] The properties of equality and inequality listed apply given a, b, and c are real numbers. In some standards, limitations may exist on the values of a, b, or c (e.g., integers only or rational numbers only), or impose other parameters (e.g., 1-step equations) that may prevent situations in which a property could be applied.

Application of Properties of Real Numbers[1] - Related to Patterns, Functions, and Algebra Strand

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Standard of Learning Description	Solve Multistep Linear Equations; Literal Equations; Systems of Linear Equations **A.4**	Solve Multistep Linear Inequalities; Systems of Linear Inequalities **A.5**
Commutative Property of Addition $a + b = b + a$	✔	✔
Commutative Property of Multiplication $ab = ba$	✔	✔
Associative Property of Addition $(a + b) + c = a + (b + c)$	✔	✔
Associative Property of Multiplication $(ab)c = a(bc)$	✔	✔
Distributive Property **(over addition/subtraction)** $a(b + c) = ab + ac$ and $a(b - c) = ab - ac$	✔	✔
Identity Property of Addition $a + 0 = a = 0 + a$	✔	✔
Identity Property of Multiplication $a \cdot 1 = a = 1 \cdot a$	✔	✔
Inverse Property of Addition $a + (-a) = 0 = (-a) + a$	✔	✔
Inverse Property of Multiplication $a \cdot \dfrac{1}{a} = 1 = \dfrac{1}{a} \cdot a, a \neq 0$	✔	✔
Multiplicative Property of Zero[†] $a \cdot 0 = 0 \cdot a$	✔	✔
Substitution Property[†] If $a = b$, then b can be substituted for a in any expression, equation or inequality	✔	✔

[1] The properties of real numbers listed apply given *a*, *b*, and *c* are real numbers. In some standards, limitations may exist on the values of *a*, *b*, or *c* (e.g., integers only or rational numbers only), or impose other parameters (e.g., one-step equations) that may prevent situations in which a property could be applied. [†] Multiplicative Property of Zero and the Substitution Property may also be considered properties of equality/inequality.

Application of Properties of Equality/Inequality[2] - Related to Patterns, Functions, and Algebra Strand

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Standard of Learning Description	Solve Multistep Linear Equations; Literal Equations; Systems of Linear Equations **A.4**	Solve Multistep Linear Inequalities; Systems of Linear Inequalities **A.5**
Addition Property of Equality If $a = b$, then $a + c = b + c$	✔	
Subtraction Property of Equality If $a = b$, then $a - c = b - c$	✔	
Multiplication Property of Equality If $a = b$, then $ac = bc$	✔	
Division Property of Equality If $a = b$ and $c \neq 0$, then $\frac{a}{c} = \frac{b}{c}$	✔	
Addition Property of Inequality If $a < b$, then $a + c < b + c$; If $a > b$, then $a + c > b + c$		✔
Subtraction Property of Inequality If $a < b$, then $a - c < b - c$; If $a > b$, then $a - c > b - c$		✔
Multiplication Property of Inequality If $a < b$ and $c > 0$, then $ac < bc$; If $a > b$ and $c > 0$, then $ac > bc$; If $a < b$ and $c < 0$, then $ac > bc$; If $a > b$ and $c < 0$, then $ac < bc$		✔
Division Property of Inequality If $a < b$ and $c > 0$, then $\frac{a}{c} < \frac{b}{c}$; If $a < b$ and $c < 0$, then $\frac{a}{c} > \frac{b}{c}$ If $a > b$ and $c > 0$, then $\frac{a}{c} > \frac{b}{c}$; If $a > b$ and $c < 0$, then $\frac{a}{c} < \frac{b}{c}$		✔
Substitution Property If $a = b$, then b can be substituted for a in any expression, equation or inequality.	✔	✔
Zero Product Property If $ab = 0$, then $a = 0$ or $b = 0$.	✔	
Reflexive Property $a = a$	✔	
Symmetric Property If $a = b$, then $b = a$.	✔	
Transitive Property If $a = b$ and $b = c$, then $a = c$.	✔	✔

[2] The properties of equality and inequality listed apply given a, b, and c are real numbers. In some standards, limitations may exist on the values of a, b, or c (e.g., integers only or rational numbers only), or impose other parameters (e.g., 1-step equations) that may prevent situations in which a property could be applied.